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This handbook for the port of La Spezia, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

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          effects of such hazardous conditions are discussed.
          Precautionary or evasive actions are suggested for
          various vessel situations. The handbook is organized in
          four sections for ready reference: general guidance on
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SEVERE WEATHER GUIDE: MEDITERRANEAN PORTS.

21. LA SPEZIA.

CONTENTS

FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Naval Environmental Prediction Research Facility to create products for direct application to Fleet operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to the Naval Environmental Prediction Research Facility for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

W. L. SHUTT
Commander, U.S. Navy

PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review.

1988 NO.	PORT
1	GAETA, ITALY
2	NAPLES, ITALY
3	CATANIA, ITALY
4	AUGUSTA BAY, ITALY
5	CAGLIARI, ITALY
6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONACO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
16	BARCELONA, SPAIN
17	PALMA, SPAIN
18	IBIZA, SPAIN
19	POLLENSA BAY, SPAIN
20	LIVORNO, ITALY
21	LA SPEZIA, ITALY
22	VENICE, ITALY
23	TRIESTE, ITALY
24	CARTAGENA, SPAIN
25	VALENCIA, SPAIN
	SAN REMO, ITALY
	GENOA, ITALY

1989	PORT
	SPLIT, YUGOSLAVIA
	DUBROVNIK, YUGOSLAVIA
	TARANTO, ITALY
	PALERMO, ITALY
	MESSINA, ITALY
	TAORMINA, ITALY
	PORTO TORRES, ITALY

1990	PORT
	BENIDORM, SPAIN
	ROTA, SPAIN
	TANGIER, MOROCCO
	PORT SAID, EGYPT
	ALEXANDRIA, EGYPT
	ALGIERS, ALGERIA
	TUNIS, TUNISIA
	GULF HAMMAMET, TUNISIA
	GULF OF GABES, TUNISIA
	SOUDA BAY, CRETE

1991	PORT
	PIRAEUS, GREECE
	KALAMATA, GREECE
	THESSALONIKI, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	VALETTA, MALTA
	LARNACA, CYPRUS

1992	PORT
	ANTALYA, TURKEY
	ISKENDERUN, TURKEY
	IZMIR, TURKEY
	ISTANBUL, TURKEY
	GOLCUK, TURKEY
	GULF OF SOLLUM

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.

B. Cruise reports were reviewed.

C. Navy personnel with current or previous area experience were interviewed.

D. A preliminary report was developed which included questions on various local conditions in specific harbors.

E. Port/harbor visits were made by NEPRF personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.

F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,

B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,

C. local wind wave conditions, and

D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2. CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested pre-cautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of La Spezia is located on the northeast shoreline of the Ligurian Sea at 44°05'N 09°51'E, near the eastern limit of the Gulf of Genoa (Figure 2-1).

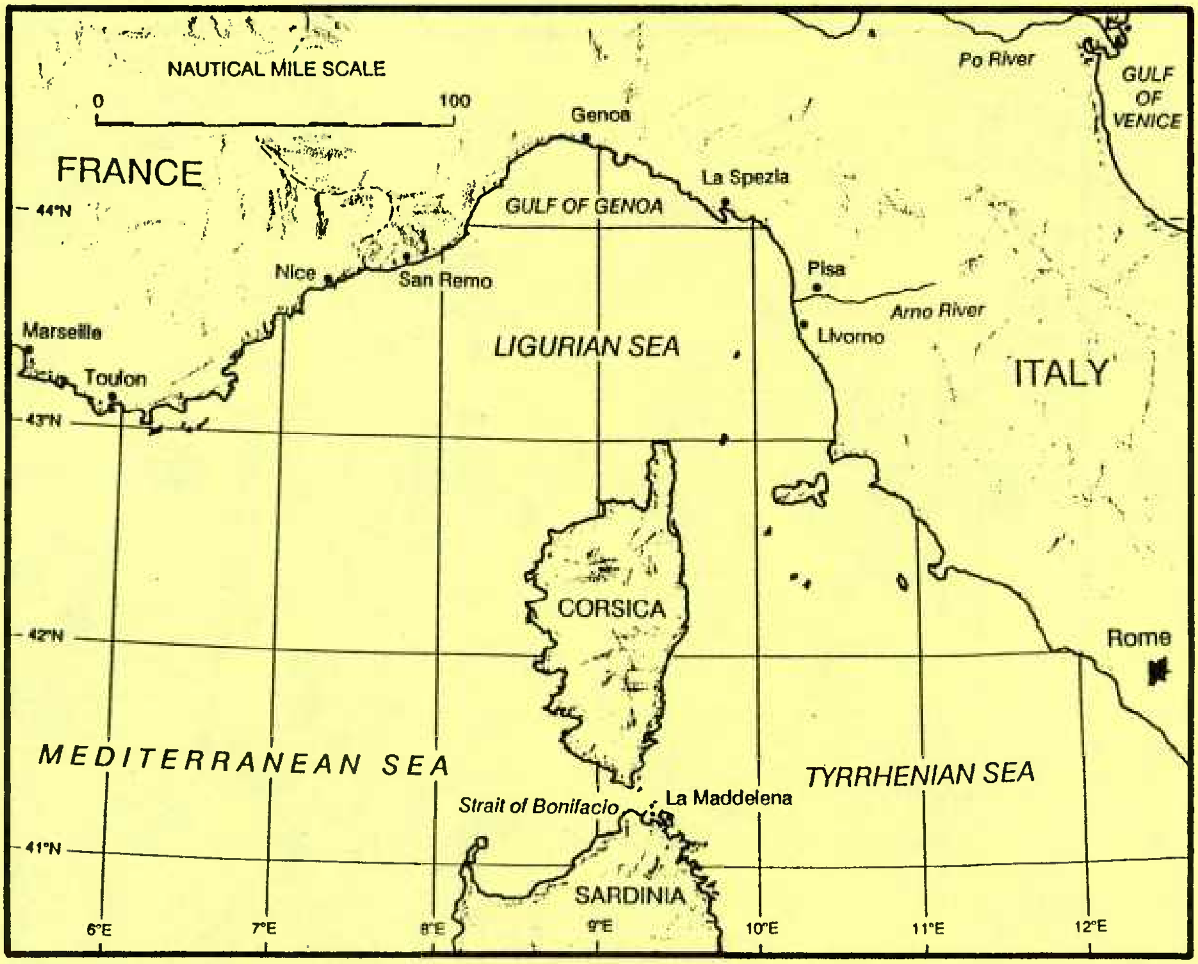

Figure 2-1. Ligurian Sea.

The spacious port is situated at the head of Golfo di La Spezia (Gulf of La Spezia), and is protected from most hazardous weather conditions. Constructed around a natural inlet with approximate dimensions of 10,000 ft (3048 m) wide by 15,000 ft (4,572 m) long, the port can easily accommodate over 40 medium- to deep-draft vessels (FICEURLANT, 1987). See Figure 2-2.

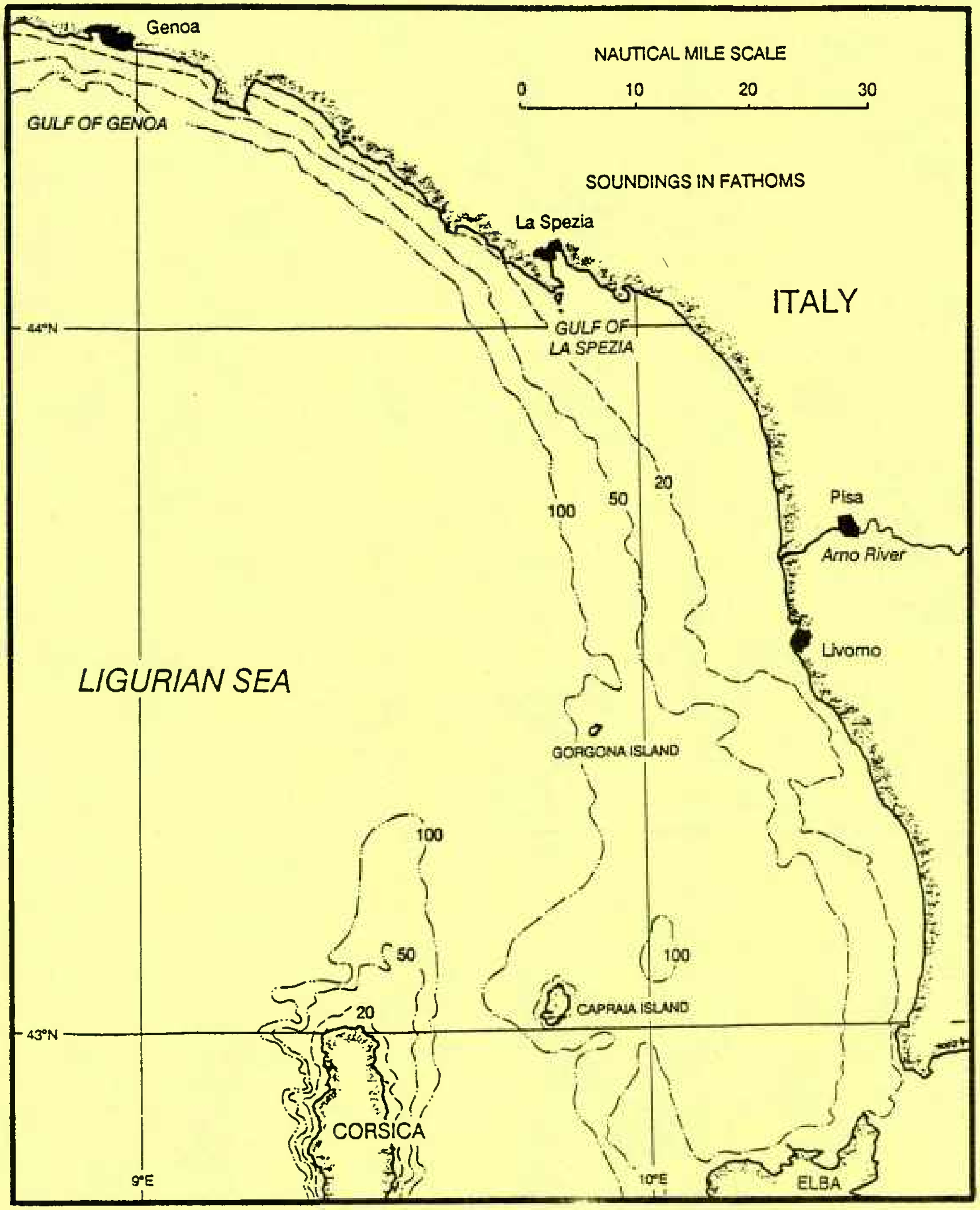

Figure 2-2. Region of the Ports of Livorno and La Spezia.

The Port of La Spezia is divided into an outer harbor and inner harbor by two breakwaters. The outer breakwater, Diga Foranea, is 7,218 ft (2,200 m) long, and forms the southern limit of the outer harbor (Figure 2-3). Two entrances to the harbor exist, with one at each end of Diga Foranea. The western entrance, with a depth of 44 ft (13.5 m) is most often used.

The inner harbor, Darsena Duca Degli Abruzzi (Porto Militare--the Italian Navy Base) is formed by the second breakwater system in the northwestern part of the Port. Small surface ships (frigate size or smaller) and submarines can "Med-moor" in the inner harbor. Entrance depth to the inner harbor is 36 ft (11 m) but is subject to silting. (In 1987, a U.S. submarine scraped bottom while entering the basin.) Fleet landing is in the Duca Degli Abruzzi at the Bachino di Revello.

Several anchorages exist at La Spezia. One is located inside the breakwater approximately 2,000 yd (1,829 m) northwest of Diga Foranea in a depth of 34.5 ft (10.5 m). Holding is rated good on a mud bottom. Two unprotected (exposed to open sea conditions) anchorages are located outside the breakwater. One is 2 n mi south (depth 86 ft) and the other is 0.6 n mi east (depth 66 ft) of Tino Island. The anchorages provide good holding on mud bottoms.

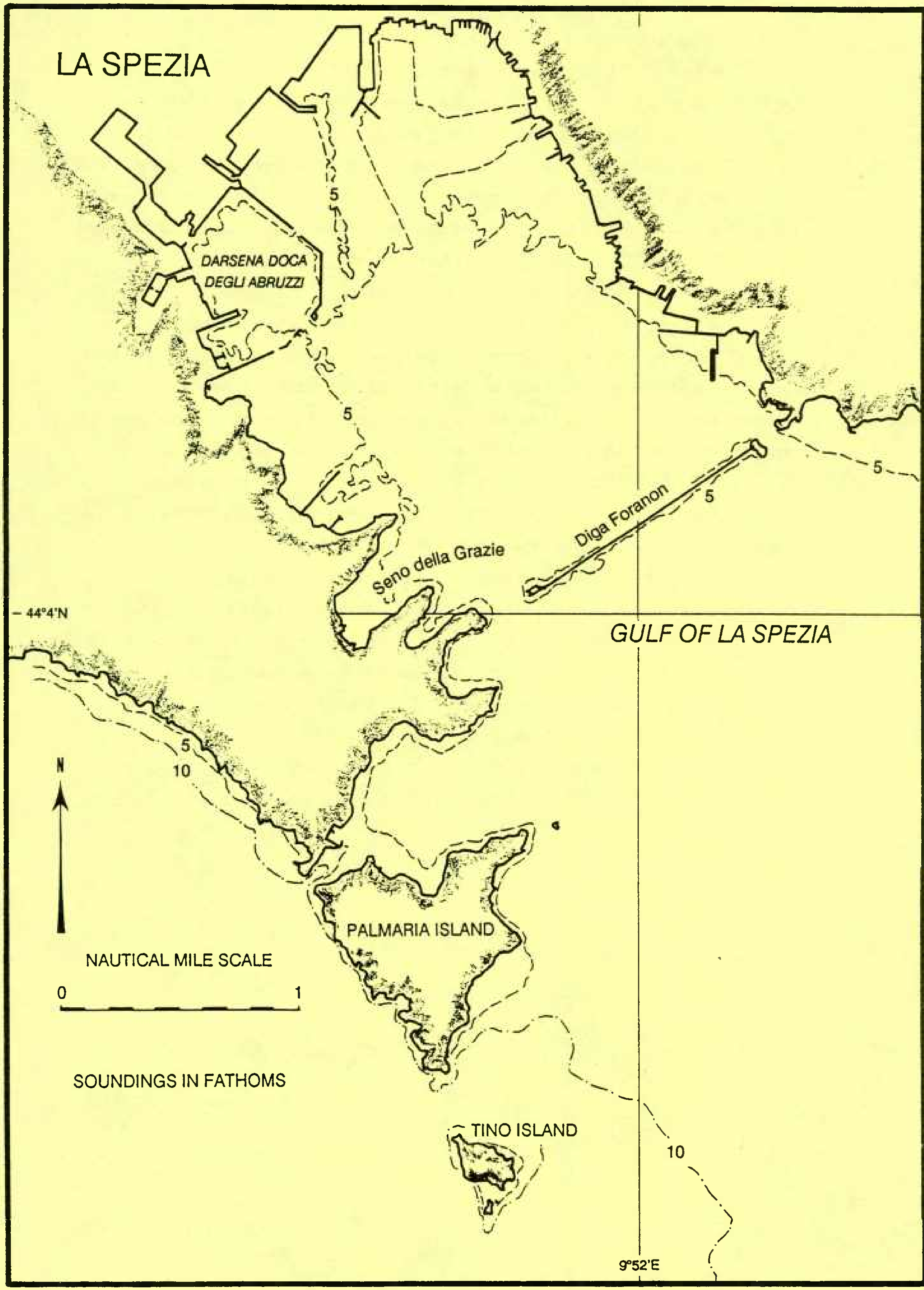

Figure 2-3. Port of La Spezia.

According to the Port Directory (FICEURLANT, 1987), most currents in the harbor are wind generated, but a weak counterclockwise current usually prevails. Tides within the harbor have a maximum variation of about 20 inches (0.5 m).

Specific hazardous conditions, vessel situations, and suggested precautionary/evasive action scenarios are summarized in Table 2-1.

Table 2-1. Summary of hazardous environmental conditions for the Port of La Spezia, Italy.

HAZARDOUS CONDITIONS	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
1. N'ly winds/waves * Wind locally called Tramontana. * Maximum velocities normally force 6 to 7 (22 to 33 kt). * Wind raises 3 ft sea in outer harbor. * Waves reflect off N side of outer breakwater, creating a chop in nearby waters.	Advance warning * Caused by building high pressure over N Italy as low pressure center moves SE of La Spezia. Duration * To be expected as long as strong high pressure dominates N Italy. * Will likely weaken quickly when signs of Genoa cyclogenesis appear.	(1) Moored - Italian Navy Base.	(a) Minimal effect - SHIPS HAVE NEVER BEEN MOVED DUE TO BAD WEATHER. * Additional mooring lines may be required in a strong event. (b) Be aware of wind chill factor.
		(2) Anchored - outer harbor.	(a) Minimal effect - SHIPS HAVE NEVER BEEN MOVED INSIDE THE BREAKWATER DUE TO BAD WEATHER. * Ships anchored near the outer breakwater may experience uncomfortable motion due to reflected waves. (b) Be aware of wind chill factor.
		(3) Anchored - outside breakwater.	(a) Minimal effect - due to limited fetch length. * Small boat runs to/from anchorage may be affected. (b) Be aware of wind chill factor.
		(4) Arriving/departing.	(a) Minimal impact. * Vessels inbound to moorings at the Italian Navy Base may need extra mooring lines. * Vessels anchoring near outer breakwater should be aware of vessel motions induced by reflected waves. (b) Be aware of wind chill factor.
		(5) Small boats.	(a) Small boat operations should be largely unaffected in the inner and outer harbors. * Small boat operators should be aware of hazards posed by reflected waves near the N side of the outer breakwater. * Runs to/from outer anchorages may be curtailed. * Local water taxis will not go outside the breakwater in winds of force 6 (22-27 kt) or greater. (b) Be aware of wind chill factor.
2. SE'ly winds/waves * Wind locally called Scirocco, but true Scirocco events occur only infrequently. * Maximum velocities normally force 7 to 8 (28 to 40 kt). * May occur 3-4 times per year. * If wind direction is SSE or S, waves may be raised in the outer anchorages.	Advance warning * Commonly associated with low pressure systems moving into or developing in the Gulf of Genoa. * Genoa lows occur almost simultaneously with the onset of a Mistral in the Gulf of Lion, and invariably form when conditions are right for a Mistral to occur. * Genoa cyclogenesis can be expected whenever a cold/occluded front passing through France reaches a lee trough which is often present in the Gulf of Genoa. * May be associated with a slowly developing Scirocco event. * Clouds forming on SE slope of Mt. Parodi may indicate the beginning of a Scirocco. Duration * A strong event may last for up to 3 days. * Commonly lasts a day or less. Associated weather * Convective activity associated with a Genoa low has a periodicity of 18 hr, starting with cold frontal passage. * Most intense activity occurs at 36 hr intervals. * Dust and/or "red rain" often accompany Scirocco winds.	(1) Moored - Italian Navy Base.	(a) Minimal effect - SHIPS HAVE NEVER BEEN MOVED DUE TO BAD WEATHER. * Additional mooring lines may be required in a strong event.
		(2) Anchored - outside breakwater.	(a) Minimal effect, unless wind is primarily from SSE or S. * SE wind would have insufficient fetch to generate hazardous waves. * SSE or S wind would have a trajectory which would cause significant waves to generate and reach the anchorages. * Evasion at sea is recommended if strong winds are forecast. * No nearby ports offer better protection.
		(3) Arriving/departing.	(a) Minimal impact on inbound/outbound vessels. * Vessels inbound to moorings at the Italian Navy Base may need extra lines. * Anchoring outside the breakwater may not be feasible due to high waves if the wind is from SSE or S (Vice SE). * Small boat runs to/from the outer anchorage may be curtailed in a strong event. Local water taxis will not go outside the breakwater in winds of force 6 (22-27 kt) or greater.
		(4) Small boats.	(a) Minimal impact on operations inside the breakwater. * BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER DUE TO BAD WEATHER. (b) Boating to/from the outer anchorage may be affected. * Waves may preclude safe boat operation in a strong event, or if the wind direction is from SSE or S (vice SE). * Local water taxis will not go outside the breakwater in winds of force 6 (22-27 kt) or greater.

Table 2-1. (Continued)

HAZARDOUS CONDITIONS	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
3. <u>SW'ly winds/waves</u> * Winds with strong W component reach the harbor as SW after passing through valleys in peninsula W of the Port. * Normally limited to force 5 (17-21 kt). * Any wind from SSW to WNW has potential to generate waves that would adversely impact the outer anchorages.	<u>Advance warning</u> * Cyclogenesis or low pressure center moving over N Italy or Gulf of Venice. * Cold/occluded frontal passage. <u>Duration</u> * Likely of short duration as winds will tend to veer through W to NW or N as pressure builds behind low or front.	(1) <u>Anchored - outside breakwater</u>.	(a) <u>The anchorage may be unusable in heavy weather</u>. * Evasion at sea is recommended if heavy weather is forecast. * No nearby ports offer better protection.
		(2) <u>Arriving/departing</u>.	(a) <u>Minimal impact on inbound/outbound vessels</u>. * Vessels will be protected from open-sea conditions when in the lee of Palmaria Island, but the protection is lost when south of the island. * Tino Island offers only limited protection close alee. * Outer anchorages are exposed and should be discounted as alternatives if heavy weather is forecast.
		(3) <u>Small boats</u>.	(a) <u>Operations inside the breakwater are only minimally affected</u>. * BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER DUE TO BAD WEATHER. (b) <u>Runs to/from the outer anchorages may be curtailed</u>. * Anchorages are exposed to open-sea conditions. * Local water taxis will not go outside the breakwater in winds of force 6 (22-27 kt) or greater.

SEASONAL SUMMARY OF LA SPEZIA HAZARDOUS WEATHER CONDITIONS

WINTER (November thru February)

* NW'ly winds: called Tramontana, may reach force 6-7 (22-33 kt), result of building high pressure over Italy as low pressure moves SE from Gulf of Genoa.
* SE'ly winds: called Scirocco caused by low pressure developing in Gulf of Genoa. Speeds up to force 7-8 (28-40 kt) expected 3-4 times/year. True Scirocco accompanied by North African dust particles ("red rain").
* W'ly winds: funneled thru two valleys on west side of port, experienced at port SW'ly (up to force 5 (17-21 kt).

SPRING (March thru May)

* High winds (99 kt - April and 63 kt - May) from unspecified direction have been recorded.
* Tramontana (NW'ly winds) and Scirocco (SE'ly winds) possible. Strongest/most frequent earlier in season.
* Sea breeze possible (afternoon).

SUMMER (June thru September)

* Sea breeze (light to moderate).
* Scattered thunderstorms.
* Small waterspouts and small tornadoes have been reported.

AUTUMN (October)

* Transition month.
* Tramontana (NW'ly winds) and Scirocco (SE'ly winds) increasing in strength and frequency.

NOTE: For more detailed information on hazardous weather conditions see previous Summary Table in this section and Hazardous Weather Summary in Section 3.

REFERENCES

FICEURLANT, 1987: Port Directory for La Spezia (1984), Italy. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards, and Table 3-2 provides a summary of vessel locations/situations, potential hazards, effect - precautionary/evasive actions, and advance indicators and other information about potential hazards by season.

3.1 Geographic Location

The Port of La Spezia is located on the northeast shoreline of the Ligurian Sea at 44°05'N 09°51'E, near the eastern limit of the Gulf of Genoa (Figure 3-1).

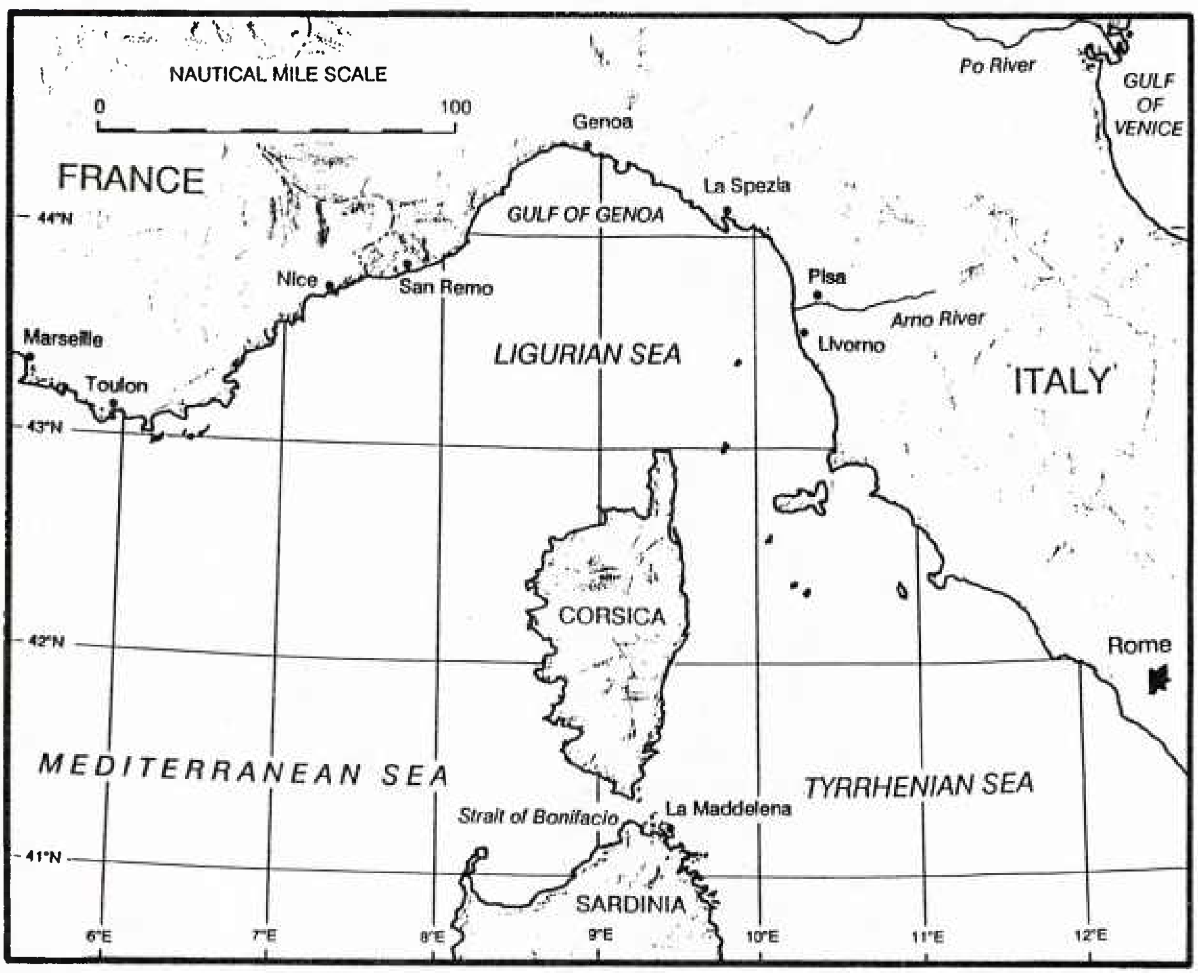

Figure 3-1. Ligurian Sea.

The spacious port is situated at the head of Golfo di La Spezia (Gulf of La Spezia), and is protected from most hazardous weather conditions. It is constructed around a natural inlet which has approximate dimensions of 10,000 ft (3,048 m) wide by 15,000 ft (4,572 m) long (Figure 3-2). It can easily accommodate over 40 medium- to deep-draft vessels (FICEURLANT, 1987).

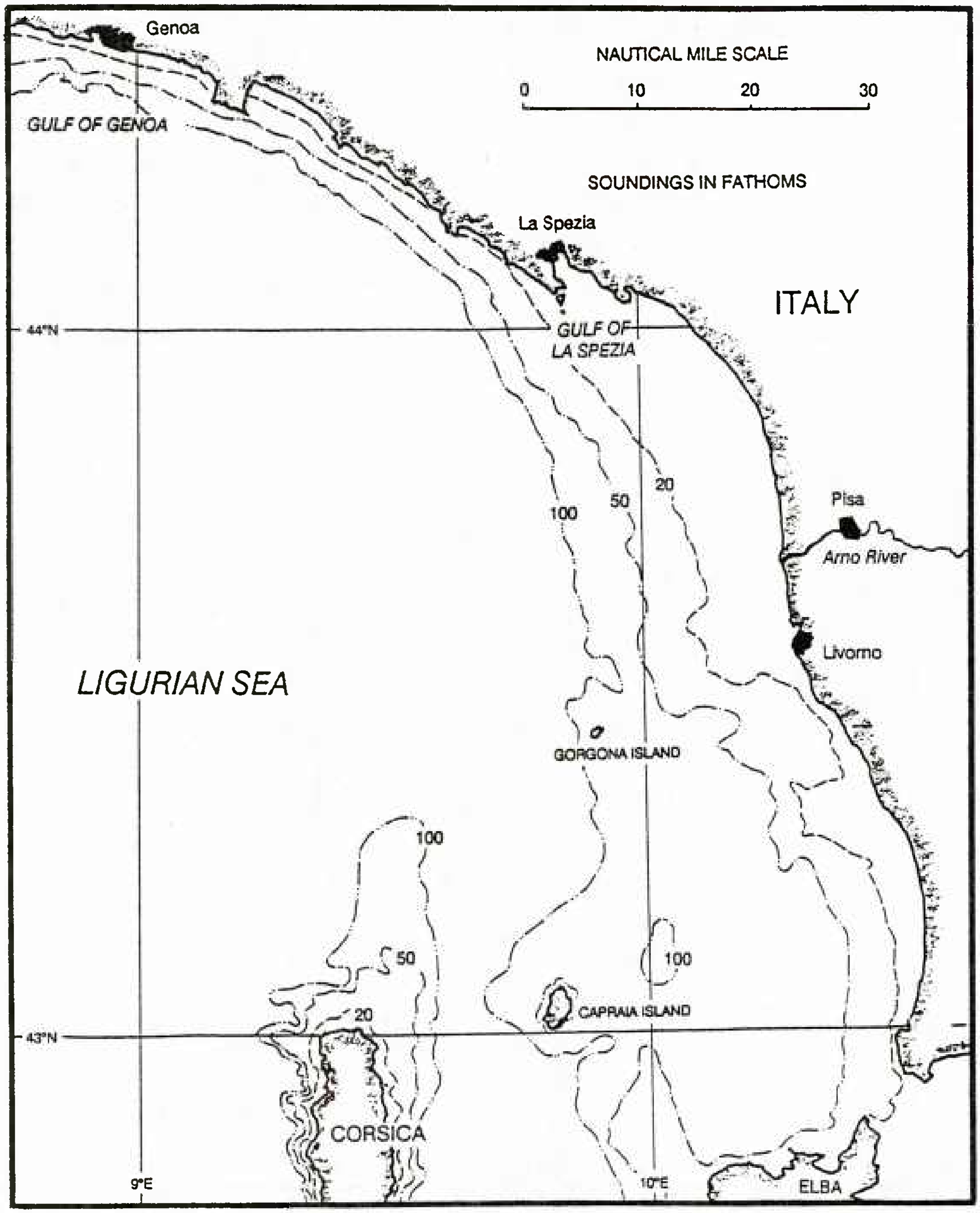

Figure 3-2. Region of the Ports of Livorno and La Spezia.

The Port of La Spezia is divided into an outer harbor and inner harbor by two breakwater systems. The outer breakwater, Diga Foranea, the surface of which is awash (Hydrographer of the Navy, 1965), is 7,218 ft (2,200 m) long, and forms the southern limit of the outer harbor (Figure 3-3). Two entrances to the harbor exist, with one at each end of Diga Foranea. The western entrance has a depth of 44 ft (13.5 m) and is most often used. The eastern entrance has a depth of 37 ft (11.5 m), but is often congested with drydock activity and moored tankers. The inner harbor, Darsena Duca Degli Abruzzi (Porto Militare--the Italian Navy Base) is formed by the second breakwater system in the northwestern part of the Port. Small surface ships (frigate size or smaller) and submarines can "Med-moor" in the inner harbor. Entrance depth to the inner harbor is 36 ft (11 m), but is subject to silting. (In 1987 a U.S. submarine scraped bottom while entering the basin.) Fleet landing is in the Duca Degli Abaruzzi at the Bachino di Revello.

Other facilities located inside the outer breakwater include commercial facilities along the north and east perimeters, and Seno Della Grazie, a cove located northwest of the western entrance to the outer harbor. Seno Della Grazie is used as a berthing place for small passenger liners (FICEURLANT, 1987).

Several anchorages exist at La Spezia. One protected anchorage is located in the outer harbor approximately 2,000 yd (1,829 m) northwest of Diga Foranea in a depth of 34.5 ft (10.5 m). Holding is rated good on a mud bottom. Two open sea (unprotected) anchorages are located outside the breakwater. One is located 2 n mi south (depth 86 ft) and 0.6 n mi east (depth 66 ft) of Tino Island. The anchorages have good holding qualities on mud bottoms.

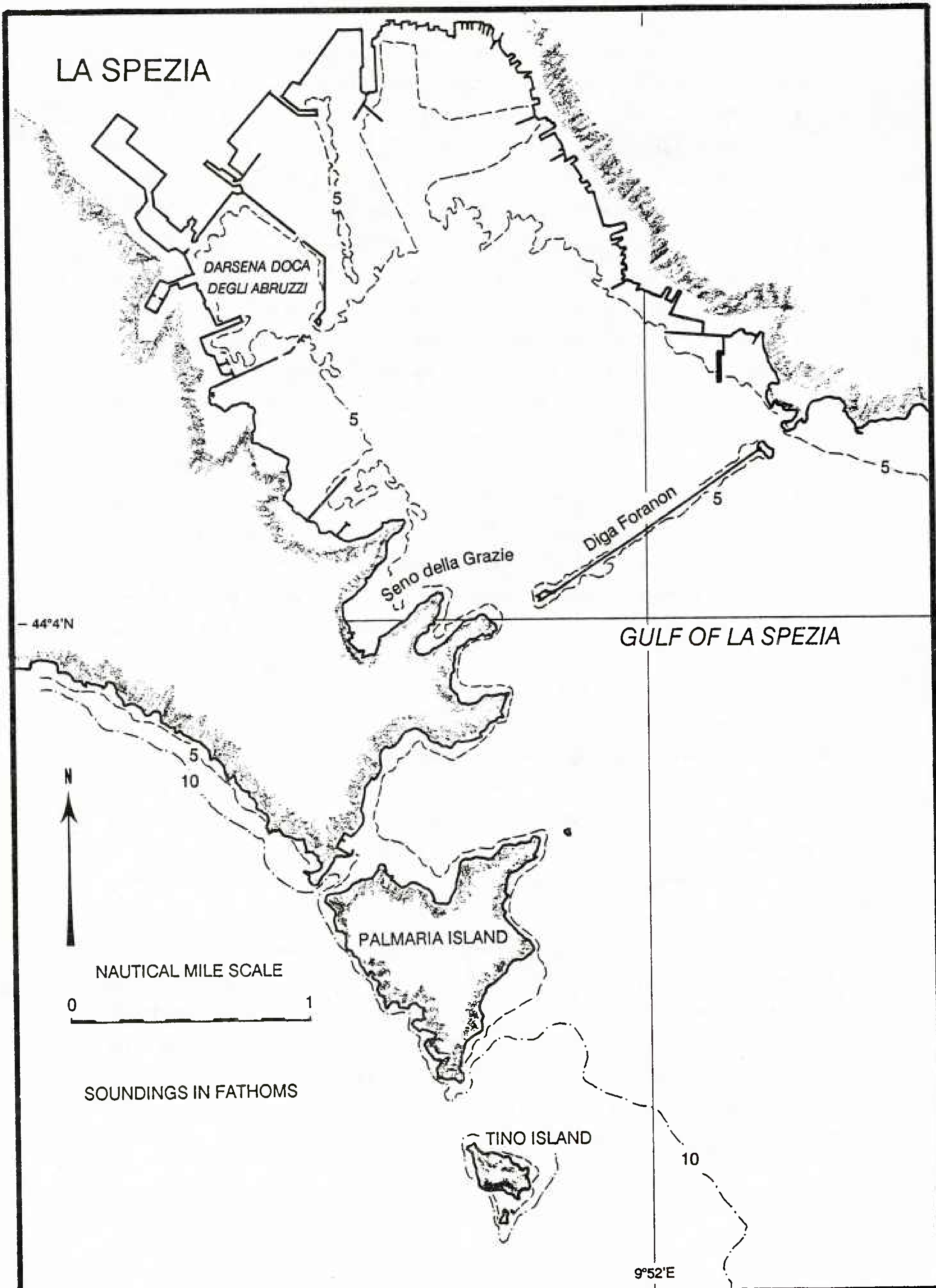

Figure 3-3. Port of La Spezia.

3.2 Qualitative Evaluation of Harbor as a Haven

The Port of La Spezia is effectively protected on three sides by steeply rising terrain. Elevations close westward of the port commonly exceed 1,500 ft (457 m), with Mt. Verrugoli reaching 2,444 ft (745 m). East of the port, elevations are somewhat lower, but some peaks exceed 1,000 ft (305 m) and one peak, Mt. Rocchetta, reaches 1,352 ft (412 m). The terrain protects the port from many high wind situations, but valleys which penetrate the mountainous areas allow some wind events to reach the harbor. Anchorages in the harbor and berths in the Italian Naval Base are relatively safe. According to local authorities, SHIPS HAVE NEVER HAD TO BE MOVED DUE TO BAD WEATHER, AND BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER. Anchorages outside the breakwater are exposed, however, and evasion at sea is recommended in heavy weather. Water taxis will not go to the outside anchorages when winds are force 6 (22-27 kt) or greater.

The inner and outer harbors are well protected from significant wave action with the exception that strong northerly winds raise a sea which reflects off the north face of Diga Foranea and causes uncomfortable, though not dangerous, motion to ships anchored nearby.

3.3 Currents and Tides

According to the Port Directory (FICEURLANT, 1987), most currents are wind generated. Local authorities state that a weak counter-clockwise current exists in the harbor. Similarly, Mediterranean Pilot (Hydrographer of the Navy, 1965) states that normally the same current exists in the whole of Golfo di La Spezia, but the current is strongly influenced by the prevailing winds.

Tides within the harbor are minimal, with a maximum range of about 20 inches (0.5 m).

3.4 Visibility

Visibility is normally good all year, but salt haze reduces visibility to 5 or 6 n mi during summer. A review of visibility statistics for the period 1951-1979 reveals that visibility restricted below 2.5 mi has the highest frequency of occurrence during the months of October through May.

3.5 Hazardous Conditions

La Spezia is located adjacent to one of the most active areas of cyclogenesis in the world, the Gulf of Genoa. Consequently, it is subject to frequent periods of unstable, inclement weather, mainly during the autumn, winter and spring seasons.

A seasonal summary of various known environmental hazards that may be encountered in the Port of La Spezia follows.

A. Winter (November through February)

Although northerly Tramontana winds are experienced during all seasons of the year, they are most frequent and stronger during winter. Maximum velocities are normally force 6 to 7 (22-33 kt). The winds have no effect at dockside due to the excellent protection afforded by the surrounding mountainous terrain. Ships anchored north of and near to Diga Foranea, the breakwater which defines the southern limit of the outer harbor, experience uncomfortable, though normally innocuous, vessel motion as northerly wind waves reflect off the north side of the breakwater. Strong Tramontana winds are the result of building high pressure over northern Italy as a low pressure center moves southeastward from the Gulf of Genoa.

Southeasterly winds are also experienced year round, abut the highest speeds are observed during winter. Although locally referred to as Scirocco, most are not of true Scirocco origin, but are instead caused by low pressure systems developing in or moving into the

Gulf of Genoa. Speeds of force 7 to 8 (28-40 kt) can be expected 3 or 4 times per year, with late winter episodes likely. Although such occurrences are relatively strong, wave heights inside the breakwater are limited to near 3 ft (about 1 m). The infrequent strong events may last up to 3 days, but the usual duration is a day or less.

True Scirocco winds are infrequently observed at La Spezia. When they occur, they are normally accompanied by dust and/or "red rain" as wind-borne particles from North Africa reach the area. Wind speeds are not normally strong.

Westerly wind regimes are experienced in the port area as southwesterly. Speeds up to force 5 (17-21 kt) occur as the winds funnel through two valleys that penetrate the steep terrain west of the Port. Effect on the Port is minimal.

Precipitation is common during winter. November has the greatest monthly accumulation of the year, about 4 inches. About 6 days in each month of the season, amounts from a trace (.01 in) to 0.4 in (9.9 mm) are recorded. Amounts of 0.4 inches (10 mm) or more are normally recorded on approximately 3 days of each month. While not frequently observed, snow is possible during the months of December, January, and February.

Temperatures during the coldest month of the season, January, range from a median low of 41°F (5°C) to a median high of 51°F (11°C). The record low temperature recorded during a 29 year period of record ending in 1979 was 20.8°F (-6.2°C). Because of the relatively cold temperatures that are common at La Spezia, the effect of wind chill (temperature combined with wind speed) should be considered for evolutions requiring personnel to work in exposed locations. Table 3-1 can be used to determine the wind chill factor for various temperature and wind speed combinations.

Table 3-1. Wind Chill. The cooling power of the wind expressed as "Equivalent Chill Temperature" (adapted from Kotsch, 1983).

Wind Speed		Cooling Power of Wind expressed as "Equivalent Chill Temperature"								
Knots	MPH	Temperature (°F)								
Calm	Calm	40	35	30	25	20	15	10	5	0
		Equivalent Chill Temperature								
3-6	5	35	30	25	20	15	10	5	0	-5
7-10	10	30	20	15	10	5	0	-10	-15	-20
11-15	15	25	15	10	0	-5	-10	-20	-25	-30
16-19	20	20	10	5	0	-10	-15	-25	-30	-35
20-23	25	15	10	0	-5	-15	-20	-30	-35	-45
24-28	30	10	5	0	-10	-20	-25	-30	-40	-50
29-32	35	10	5	-5	-10	-20	-30	-35	-40	-50
33-36	40	10	0	-5	-15	-20	-30	-35	-45	-55

B. Spring (March through May)

The spring season is characterized by periods of stormy, winter-type weather which alternates with a number of false starts of relatively settled summer-type weather (Brody and Nestor, 1980). The more unsettled periods occur during March and April, when low pressure systems develop in or pass through the Gulf of Genoa. After April, the transition to settled weather proceeds more smoothly. Although strong winds are not the rule at La Spezia, a potential for damaging winds exists. This possibility is evidenced by the fact that the climatology record from Palmaria Island (Figure 3-3) indicates speeds of 99 kt have been recorded during April, and 62 kt during May. The direction was not specified in either instance, but the existence of such a wind in the past indicates the possibility of a similar event in the future cannot be discounted.

Northerly Tramontana winds are possible throughout the season, but are strongest early in the period because the high pressure systems over northern Italy become less strong as the season progresses.

Southeasterly winds are also experienced throughout the season, and like the Tramontana, are strongest early in the season when Genoa lows are the strongest.

Scirocco events are possible early in the season and can bring dust and/or "red rain" to La Spezia.

Prevailing night and early morning winds are northerly, but southwesterly winds are the rule by mid-afternoon as a sea breeze regime becomes evident on warm days early in the season.

Precipitation amounts remain near the wintertime levels through March, but decrease thereafter.

Temperatures warm throughout the season as summer approaches. By May, the mean daily maximum temperature has risen to 67°F (19°C), while the minimum has risen to 55°F (13°C). Wind chill factor is a consideration until late April. See Table 3-1.

C. Summer (June through September)

Summer is a period of relatively warm, settled conditions at La Spezia. Strong winds are uncommon, but velocities of 60 kt have been recorded during August, and 55 kt during September.

Night and early morning winds are normally from the north, with southwesterly winds common during the afternoon. Warmest temperatures are observed during July and August, with a mean daily maximum of 79°F (26°C). Precipitation is at its yearly minimum in July, when less than 1 inch of rain accumulates during an average year. The monthly total increases to almost 3 inches by September.

La Spezia experiences scattered thunderstorms during the summer. Small waterspouts and tornadoes have also been reported.

D. Autumn (October)

Autumn usually lasts for the single month of October and is characterized by an abrupt change to winter-type weather (Brody and Nestor, 1980).

The possibility of stronger northerly Tramontana wind increases as influxes of cold air begin to invade Europe in advance of the winter season. Similarly, the threat of stronger southeasterly winds increases as cyclonic activity in the Gulf of Genoa starts to become more common.

Temperatures decrease from those of summer, with a mean maximum of about 67°F (19°C) and mean minimum of 55°F (13°C) normal for October. Precipitation amounts increase from those of September, with an average accumulation of 3.76 inches occurring on about 7.5 days during the month. Thunderstorms occur on an average of 3 days during October, the greatest frequency of the year.

3.6 Harbor Protection

The Port of La Spezia is afforded excellent protection from most wind and wave conditions, but is vulnerable to certain specific events. Also, as detailed below, there are differences in protection enjoyed by vessels inside the breakwaters and those anchored in open sea conditions.

3.6.1 Wind and Weather

The inner and outer harbors are bordered on 3 sides (west, north, and east) by steeply rising terrain which serves to block or reduce the speed of many wind regimes. Relatively strong winds reach the port, however, from the southeast, southwest, and north. Anchorages in the harbor and berths in the Italian Naval Base (Darsena Duca Degli Abruzzi) are relatively safe; SHIPS HAVE NEVER HAD TO BE MOVED DUE TO BAD WEATHER AND BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER. However, water taxis will not go to the outside anchorages when winds are force 6 (22-27 kt) or greater.

The harbor affords no effective protection from thunderstorms nor the infrequently seen small waterspouts and tornadoes.

3.6.2 Waves

Inside the breakwater, wave action is limited to those which are raised by the local wind. Since the maximum straight line distance across the harbor inside the breakwater (Diga Foranea) is only 2.5 n mi, wave generation is fetch limited. Southerly winds of force 7 to 8 (28-40 kt) only raise a 3 ft (about 1 m) sea inside the breakwater, so operations are only minimally affected. The same situation applies to northerly winds, but with a different result. According to local authorities, northerly waves reflect off the north face of Diga Foranea and cause "uncomfortable, though not usually damaging", vessel motion to ships anchored near the breakwater.

Vessels anchored in the two outside anchorages are exposed to open sea conditions. Consequently, any wave condition which emanates from south through northwest has the potential to reach the anchorages.

3.7 Protective/Mitigating Measures

3.7.1 Sortie/Remain in Port

Vessels at the Italian Naval Base should be able to remain in Port. SORTIE HAS NEVER BEEN NECESSARY DUE TO BAD WEATHER IN THE PORT OF LA SPEZIA.

3.7.2 Moving to a New Anchorage

Vessels anchored in the harbor should be able to stay; SHIPS HAVE NEVER HAD TO BE MOVED DUE TO BAD WEATHER. But because they are exposed to open-sea conditions, ships in the two anchorages outside the breakwater, 0.6 n mi east and 2 n mi south of Tino Island, should evade at sea if heavy weather is forecast. There are no good alternate anchorages near La Spezia in which to seek haven.

3.8 Local Indicators of Hazardous Weather Conditions

The Port of La Spezia affords excellent shelter from most hazardous weather conditions, but it is prudent to be aware of potential hazards and have insight as to when specific conditions may develop. The following guidelines have been extracted from various sources, including on-site interviews with local authorities. They are intended to provide additional insight to the Fleet meteorologists, and enable them to recognize events that indicate changes in weather conditions. Unless otherwise indicated the guidelines have been adapted from Regional Forecasting Aids for the Mediterranean Basin, (Brody and Nestor, 1980).

3.8.1 Genoa Lows, the Primary Cause of Southeasterly Winds at La Spezia.

A. Cyclogenesis

1. A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. This lee trough remains stationary until the arrival of the front, at which time significant cyclogenesis occurs.

2. A good indication of rapid development of a Genoa low is the appearance of cold air from the northeast in the Po Valley of northern Italy.

3. If Genoa cyclogenesis is predicted, the following rules can be used to decide whether it will occur in the Gulf of Genoa or to the east in the Gulf of Venice:

a. If large amounts of cold air penetrate the Po Valley from the northeast, cyclogenesis can be expected in the Gulf of Genoa. This cyclone generally will move southeastward along the west coast of Italy.

b. If little cold air penetrates the Po Valley from the northeast while a strong push is observed in the Gulf of Lion, cyclogenesis will probably take place in the Gulf of Venice. This cyclone occasionally may move southeast through the Adriatic Sea.

4. Genoa lows occur almost simultaneously with the onset of the Mistral in the Gulf of

Lion, and invariably form when conditions are right for the Mistral to occur.

5. Complex low pressure systems with multiple centers at the surface are a common event in the western Mediterranean Basin. One center usually can be found in the gulf of Genoa, while another is found over North Africa; a weak pressure gradient exists between the two systems. Which of these lows will develop depends greatly on the movement of an upper-level (500 mb) short wave trough. If the trough moves to the North African coast, for example, the low center in that region will develop rapidly, increasing the pressure gradient and causing easterly gales over the southern Tyrrhenian Sea.

B. <u>Associated wind and weather</u>

1. Weak to moderate Genoa cyclogenesis causes important variations in the weather along the west coast of Italy. When analyzing these cases, the resolution of the 500 mb analysis should be fine enough to support tracking of the weak short wave troughs associated with increased shower activity.

2. Convective activity associated with a Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage. The periodicity is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals.

3. Strong westerly winds associated with Mistral conditions rarely reach the west coast of Italy. Winds usually will not reach gale force until after the associated Genoa low moves off to the southeast. Under these conditions gale force northeasterly winds occur along the west coast of Italy.

4. Strong northerly winds can be expected in the Gulf of Genoa within 6-8 hr if (1) the 1034 mb isobar is present along the crest of the Alps north of the Gulf of Genoa and (2) increasing northerly winds are observed at Milan (16080).

C. <u>Miscellaneous</u>

1. A residual low pressure trough generally remains over the Gulf of Genoa even after the

primary low has moved well out of the region. The trough can remain for several days.

2. Centers of Genoa lows can be poorly organized; strong pressure gradients, associated with a lee trough south of the Alps, frequently are found far from the low's geographic center.

3.8.2 Scirocco

A. During Scirocco periods over the Mediterranean, a low-level jet is likely to exist just below the top of the very marked temperature inversion common during the Scirocco. Wind speeds reaching 70-80 kt, with heavy turbulence associated with the strong vertical wind shear, have been observed in the jet.

B. Local indicators

The following guidelines were related by local authorities:

1. Scirocco winds usually will increase gradually, so ample advance warning is provided by the time taken to develop a full Scirocco situation.

2. Clouds forming on the southeast slope of Mount Parodi (northwest of La Spezia) may indicate the beginning of a Scirocco.

3.8.3 General

A. Past experience indicates that the reliability of hourly reporting stations along the Italian coast is questionable, especially during the night.

B. During periods of southerly surface flow in the central Mediterranean, convergence zones between southeasterly and southwesterly winds are frequently observed. These convergence zones result in heavier precipitation and lower visibilities. Fronts are not associated with this phenomenon initially, but may develop later.

C. During the winter half of the year along the west coast of Italy, maximum occurrence of convective activity is in the early morning (0300-0800L) and minimum occurrence is in the late afternoon and early evening. In the mountains to the east, however, this diurnal variation is reversed.

D. Dry, moderate-to-strong (15-25 kt), north-to-east winds during the winter have produced steam fog along the Italian coast from Genoa to Pisa, out to 35 n mi offshore. Visibilities in this fog are reduced to 1-2 n mi although the dewpoint-temperature spread measured at an aircraft carrier's flight deck level may exceed 4°F.

E. Local authorities state that clouds forming on the southeast slope of Mount Parodi (northwest of La Spezia) may indicate the beginning of a period of bad weather and rain is about to start.

3.9 Summary of Problems, Actions, and Indicators

Table 3-2 is intended to provide easy to use seasonal references for meteorologists on ships using the Port of La Spezia. Table 2-1 (section 2) summarizes Table 3-2 and is intended primarily for use by ship captains.

Table 3-2. Potential problem situations at Port of La Spezia, Italy - ALL SEASONS.

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
1. Moored - Italian Navy Base. Strongest in Winter Occurs in Spring Summer and Autumn	a. N'ly winds - Locally called Tramontana. Caused by building high pressure over northern Italy as a low pressure center moves SE from the Gulf of Genoa. Maximum winds normally force 6 to 7 (22-33 kt).	a. Minimal effect. Additional mooring lines may be required in a strong event. SHIPS HAVE NEVER BEEN MOVED DUE TO BAD WEATHER. Be aware of wind chill factor.	a. N'ly winds are the result of building high pressures over N Italy and a SE'ly moving low pressure center.
Strongest in Winter Occurs in Spring Summer and Autumn	b. SE'ly winds - Locally called Scirocco. Caused by low pressure systems developing in or moving into the Gulf of Genoa. Velocities to force 7 to 8 (28-40 kt) can be expected 3-4 times per year. Stronger events may last up to 3 days, but the usual duration is a day or less. True Scirocco events occur infrequently and are normally accompanied by dust and/or "red rain" as wind borne particles from North Africa reach the area.	b. Minimal effect. Additional mooring lines may be required in a strong event. SHIPS HAVE NEVER BEEN MOVED DUE TO BAD WEATHER.	b. SE'ly winds at La Spezia are most often caused by low pressure systems located in the Gulf of Genoa, but are infrequently caused by Scirocco events. (1) Genoa lows. The following is an abbreviated listing of various aspects of Genoa low behavior. (a) Cyclogenesis 1. A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. The trough remains stationary until arrival of the front, at which time significant cyclogenesis occurs. 2. A good indication of rapid development of a Genoa low is the appearance of cold air from the NE in the Po Valley. 3. Genoa lows occur almost simultaneously with the onset of a Mistral in the Gulf of Lion, and invariably form when conditions are right for a Mistral to occur. (b) Associated weather: Convective activity associated with a Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage, and is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals. (c) Miscellaneous 1. A residual low pressure trough generally remains over the Gulf of Genoa even after the primary low has moved well out of the region. The trough can remain several days. 2. Centers of Genoa lows can be poorly organized: Strong pressure gradients frequently are found far from the low's geographic center. (2) Scirocco events (a) Clouds forming on the SE slope of Mt. Parodi (NW of La Spezia) may indicate the beginning of a Scirocco. (b) Scirocco winds usually will increase slowly, so ample advance warning is provided by the time taken to develop a full Scirocco situation.
2. Anchored - outer harbor. Strongest in Winter Occurs in Spring Summer and Autumn	a. N'ly winds/waves - Locally called Tramontana. Caused by building high pressure over northern Italy as a low pressure center moves SE from the Gulf of Genoa. Maximum winds normally force 6 to 7 (22-33 kt). Raises a N'ly sea to 3 ft in the outer harbor which reflects off of the N side of the outer breakwater and creates a chop in the nearby waters.	a. Wind alone causes no significant problem, but reflected waves cause uncomfortable, but not usually damaging, vessel motions to vessels anchored near the breakwater. SHIPS HAVE NEVER BEEN MOVED DUE TO BAD WEATHER. Be aware of wind chill factor.	a. N'ly winds are the result of building high pressures over N Italy and a SE'ly moving low pressure center.

Table 3-2. (Continued)

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
3. Anchored - outside breakwater. Strongest in Winter Occurs in Spring and Autumn Weakest in Summer	a. N'ly winds - Locally called Tramontana. Caused by building high pressure over northern Italy as a low pressure center moves SE from the Gulf of Genoa. Maximum winds normally force 6 to 7 (22-33 kt).	a. Configuration of coastline minimizes the impact of wind and waves. Winds blowing S toward anchorages would have insufficient fetch length to raise a sea hazardous to anchored vessels. Small boat runs to/from the inner harbor may be affected. Be aware of wind chill factor.	a. N'ly winds are the result of building high pressures over N Italy and a SE'ly moving low pressure center.
Strongest in Winter Occurs in Spring and Autumn Weakest in Summer	b. SE'ly winds - Locally called Scirocco. Caused by low pressure systems developing in or moving into the Gulf of Genoa. Velocities to force 7 to 8 (28-40 kt) can be expected 3-4 times per year. Stronger events may last up to 3 days, but the usual duration is a day or less. True Scirocco events occur infrequently and are normally accompanied by dust and/or "red rain" as wind borne particles from North Africa reach the area.	b. Configuration of coastline minimizes the effect of any wind with a significant E component, but winds from SSE or S could raise waves that would impact the anchorages. Evasion at sea is recommended if heavy weather is forecast.	b. SE'ly winds at La Spezia are most often caused by low pressure systems located in the Gulf of Genoa, but are infrequently caused by Scirocco events. (1) Genoa lows. The following is an abbreviated listing of various aspects of Genoa low behavior. (a) Cyclogenesis 1. A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. The trough remains stationary until arrival of the front, at which time significant cyclogenesis occurs. 2. A good indication of rapid development of a Genoa low is the appearance of cold air from the NE in the Po Valley. 3. Genoa lows occur almost simultaneously with the onset of a Mistral in the Gulf of Lion, and invariably form when conditions are right for a Mistral to occur. (b) Associated weather: Convective activity associated with a Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage, and is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals. (c) Miscellaneous 1. A residual low pressure trough generally remains over the Gulf of Genoa even after the primary low has moved well out of the region. The trough can remain several days. 2. Centers of Genoa lows can be poorly organized: Strong pressure gradients frequently are found far from the low's geographic center. (2) Scirocco events (a) Clouds forming on the SE slope of Mt. Parodi (NW of La Spezia) may indicate the beginning of a Scirocco. (b) Scirocco winds usually will increase slowly, so ample advance warning is provided by the time taken to develop a full Scirocco situation.
Strongest in Winter Occurs in Spring Summer and Autumn	c. SW'ly winds/waves - Any relatively strong wind with a direction from SW through WNW has the potential to generate sea/swell that would adversely impact the anchorages. Any wind with a strong W component would reach the inner harbor as SW after passing through valleys in peninsula W of the Port. Normally limited to force 5 (17-21 kt) in harbor area. May be caused by low pressure N and/or NE of La Spezia or as post frontal winds following passage of a cold/occluded front.	c. The anchorages are exposed to winds/waves from SSE through WNW. Evasion at sea is recommended if heavy weather is forecast.	c. Cyclogenesis or low pressure center moving over N Italy or Gulf of Venice may result in SW wind at La Spezia. SW to W winds may follow the passage of a cold or occluded front. If high pressure builds in behind a SE'ly moving low pressure center, the winds will likely continue to veer, becoming N as the low moves.

Table 3-2. (Continued)

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
4. <u>Arriving/departing.</u> Strongest in Winter Occurs in Spring and Autumn Weakest in Summer	a. <u>N'ly winds/waves</u> - Locally called Tramontana. Caused by building high pressure over northern Italy as a low pressure center moves SE from the Gulf of Genoa. Maximum winds normally force 6 to 7 (22-33 kt). Raises a N'ly sea to 3 ft in the outer harbor which reflects off the N side of the outer breakwater and creates a chop in the nearby waters.	a. Inbound/outbound vessels should not encounter any significant problems while entering or leaving the Port. Ships inbound to the Italian Navy Base may need extra lines for mooring. Ships intending to anchor in the outer harbor near the breakwater should be aware of the bothersome chop created by reflected wind waves. Be aware of wind chill factor.	a. N'ly winds are the result of building high pressures over N Italy and a SE'ly moving low pressure center.
Strongest in Winter Occurs in Spring and Autumn Weakest in Summer	b. <u>SE'ly winds</u> - Locally called Scirocco. Caused by low pressure systems developing in or moving into the Gulf of Genoa. Velocities to force 7 to 8 (28-40 kt) can be expected 3-4 times per year. Stronger events may last up to 3 days, but the usual duration is a day or less. True Scirocco events occur infrequently and are normally accompanied by dust and/or "red rain" as wind borne particles from North Africa reach the area.	b. Inbound/outbound vessels should not encounter any significant problems while entering or leaving the Port. Ships inbound to the Italian Navy Base may need extra lines for mooring. Ships intending to anchor outside the outer breakwater should be aware of problems caused by winds from SSE or S.	b. SE'ly winds at La Spezia are most often caused by low pressure systems located in the Gulf of Genoa, but are infrequently caused by Scirocco events. (1) <u>Genoa lows.</u> The following is an abbreviated listing of various aspects of Genoa low behavior. (a) <u>Cyclogenesis</u> <u>1.</u> A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. The trough remains stationary until arrival of the front, at which time significant cyclogenesis occurs. <u>2.</u> A good indication of rapid development of a Genoa low is the appearance of cold air from the NE in the Po Valley. <u>3.</u> Genoa lows occur almost simultaneously with the onset of a Mistral in the Gulf of Lion, and invariably form when conditions are right for a Mistral to occur. (b) <u>Associated weather:</u> Convective activity associated with a Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage, and is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals. (c) <u>Miscellaneous</u> <u>1.</u> A residual low pressure trough generally remains over the Gulf of Genoa even after the primary low has moved well out of the region. The trough can remain several days. <u>2.</u> Centers of Genoa lows can be poorly organized: Strong pressure gradients frequently are found far from the low's geographic center. (2) <u>Scirocco events</u> (a) Clouds forming on the SE slope of Mt. Parodi (NW of La Spezia) may indicate the beginning of a Scirocco. (b) Scirocco winds usually will increase slowly, so ample advance warning is provided by the time taken to develop a full Scirocco situation.
Strongest in Winter Occurs in Spring Summer and Autumn	c. <u>SW'ly winds/waves</u> - Any relatively strong wind with a direction from SW through WNW has the potential to generate sea/swell that would adversely impact the outer anchorages. Any wind with a strong W component would reach the inner harbor as SW after passing through valleys in peninsula W of the Port. Normally limited to force 5 (17-21 kt) in harbor area. May be caused by low pressure N and/or NE of La Spezia or as post frontal winds following passage of a cold/occluded front.	c. Inbound/outbound vessels should experience no significant problems entering or leaving Port when in the lee of Palmaria Island and the peninsula which forms the western side of Rada De La Spezia. Once the lee is lost however, vessels are exposed to open-sea conditions. The outer anchorages are exposed, and are not viable alternatives during heavy weather.	c. Cyclogenesis or low pressure center moving over N Italy or Gulf of Venice may result in SW wind at La Spezia. SW to W winds may follow the passage of a cold or occluded front. If high pressure builds in behind a SE'ly moving low pressure center, the winds will likely continue to veer, becoming N as the low moves.

Table 3-2. (Continued)

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
5. Small boats. Strongest in Winter Occurs in Spring and Autumn Weakest in Summer	a. N'ly winds/waves - Locally called Tramontana. Caused by building high pressure over northern Italy as a low pressure center moves SE from the Gulf of Genoa. Maximum winds normally force 6 to 7 (22-33 kt). Raises a N'ly sea to 3 ft in the outer harbor which reflects off the N side of the outer breakwater and creates a chop in the nearby waters.	a. Winds/waves pose no problem in the inner harbor. Since wave heights are limited to about 3 ft in a strong situation, operations in the outer harbor may still be conducted. Caution is necessary in the chop raised by the reflected wind waves near the outer breakwater. BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER DUE TO BAD WEATHER. Boating to/from the breakwater and the outer anchorages may be curtailed in a strong event. Be aware of wind chill factor.	a. N'ly winds are the result of building high pressures over N Italy and a SE'ly moving low pressure center.
Strongest in Winter Occurs in Spring and Autumn Weakest in Summer	b. SE'ly winds - Locally called Scirocco. Caused by low pressure systems developing in or moving into the Gulf of Genoa. Velocities to force 7 to 8 (28-40 kt) can be expected 3-4 times per year. Stronger events may last up to 3 days, but the usual duration is a day or less. True Scirocco events occur infrequently and are normally accompanied by dust and/or "red rain" as wind borne particles from North Africa reach the area.	b. Winds/waves pose no problem in the harbor due to lack of significant fetch length. BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER DUE TO BAD WEATHER. Boating to/from the breakwater and the outer anchorages may be curtailed in a strong event or if the wind is from SSE or S. Local water taxis will not go outside the breakwater in winds of force 6 (22-27 kt) or greater.	b. SE'ly winds at La Spezia are most often caused by low pressure systems located in the Gulf of Genoa, but are infrequently caused by Scirocco events. (1) Genoa lows. The following is an abbreviated listing of various aspects of Genoa low behavior. (a) Cyclogenesis 1. A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. The trough remains stationary until arrival of the front, at which time significant cyclogenesis occurs. 2. A good indication of rapid development of a Genoa low is the appearance of cold air from the NE in the Po Valley. 3. Genoa lows occur almost simultaneously with the onset of a Mistral in the Gulf of Lion, and invariably form when conditions are right for a Mistral to occur. (b) Associated weather: Convective activity associated with a Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage, and is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals. (c) Miscellaneous 1. A residual low pressure trough generally remains over the Gulf of Genoa even after the primary low has moved well out of the region. The trough can remain several days. 2. Centers of Genoa lows can be poorly organized: Strong pressure gradients frequently are found far from the low's geographic center. (2) Scirocco events (a) Clouds forming on the SE slope of Mt. Parodi (NW of La Spezia) may indicate the beginning of a Scirocco. (b) Scirocco winds usually will increase slowly, so ample advance warning is provided by the time taken to develop a full Scirocco situation.
Strongest in Winter Occurs in Spring Summer and Autumn	c. SW'ly winds/waves - Any relatively strong wind with a direction from SW through WNW has the potential to generate sea/swell that would adversely affect boat runs to the outer anchorages. Any wind with a strong W component would reach the inner harbor as SW after passing through valleys in peninsula W of the Port. Normally limited to force 5 (17-21 kt) in harbor area. May be caused by low pressure N and/or NE of La Spezia or as post frontal winds following passage of a cold/occluded front.	c. Operations inside the outer breakwater are not significantly affected. BOATING HAS NEVER BEEN CANCELLED INSIDE THE BREAKWATER DUE TO BAD WEATHER. Boating to/from the outer anchorages may not be feasible once the lee of Palmaria Island and the peninsula on the W side of Rada de La Spezia is lost.	c. Cyclogenesis or low pressure center moving over N Italy or Gulf of Venice may result in SW wind at La Spezia. SW to W winds may follow the passage of a cold or occluded front. If high pressure builds in behind a SE'ly moving low pressure center, the winds will likely continue to veer, becoming N as the low moves.

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PORT VISIT INFORMATION

AUGUST 1987. NEPRF meteorologists R. Fett and D. Perryman met with the Port Captain Como Marzaroli and Chief Pilot Mr. Casareto to obtain much of the information included in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides general information on wave forecasting and wave climatology as used in this study. The forecasting material is not harbor specific. The material in paragraphs A.1 and A.2 was extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955). The information on fully arisen wave conditions (A.3) and wave conditions within the fetch region (A.4) is based on the JONSWAP model. This model was developed from measurements of wind wave growth over the North Sea in 1973. The JONSWAP model is considered more appropriate for an enclosed sea where residual wave activity is minimal and the onset and end of locally forced wind events occur rapidly (Thornton, 1986), and where waves are fetch limited and growing (Hasselmann, et al., 1976). Enclosed sea, rapid onset/subsiding local winds, and fetch limited waves are more representative of the Mediterranean waves and winds than the conditions of the North Atlantic from which data was used for the Pierson and Moskowitz (P-M) Spectra (Neumann and Pierson 1966). The P-M model refined the original spectra of H.O. 603, which over developed wave heights.

The primary difference in the results of the JONSWAP and P-M models is that it takes the JONSWAP model longer to reach a given height or fully developed seas. In part this reflects the different starting wave conditions. Because the propagation of waves from surrounding areas into semi-enclosed seas, bays, harbors, etc. is limited, there is little residual wave action following periods of locally light/calm winds and the sea surface is nearly flat. A local wind developed wave growth is therefore slower than wave growth in the open ocean where some residual wave action is generally always present. This slower wave development is a built in bias in the formulation of the JONSWAP model which is based on data collected in an enclosed sea.

A.1 Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN- BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period ($f = 1/T$) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A.2 Wave Spectrum

Wave characteristics are best described by means of their range of frequencies and directions or their spectrum and the shape of the spectrum. If the spectrum of the waves covers a wide range of frequencies and directions (known as short-crested conditions), SEA conditions prevail. If the spectrum covers a narrow range of frequencies and directions (long crested conditions), SWELL conditions prevail. The wave spectrum depends on the duration of the wind, length of the fetch, and on the wind velocity. At a given wind speed and a given state of wave development, each spectrum has a band of frequencies where most of the total energy is concentrated. As the wind speed increases the range of significant frequencies extends more and more toward lower frequencies (longer periods). The frequency of maximum energy is given in equation 1.1 where v is the wind speed in knots.

$$f_{max} = \frac{2.476}{v} \qquad (1.1)$$

The wave energy, being a function of height squared, increases rapidly as the wind speed increases and the maximum energy band shifts to lower frequencies. This results in the new developing smaller waves (higher frequencies) becoming less significant in the energy spectrum as well as to the observer. As larger waves develop an observer will pay less and less attention to the small waves. At the low frequency (high period) end the energy drops off rapidly, the longest waves are relatively low and extremely flat, and therefore also masked by the high energy frequencies. The result is that 5% of the upper frequencies and 3% of the lower frequencies can be cut-off and only the remaining frequencies are considered as the "significant part of the wave spectrum". The resulting range of significant frequencies or periods are used in defining a fully arisen sea. For a fully arisen sea the approximate average period for a given wind speed can be determined from equation (1.2).

$$\bar{T} = 0.285v \tag{1.2}$$

Where v is wind speed in knots and T is period in seconds. The approximate average wave length in a fully arisen sea is given by equation (1.3).

$$\bar{L} = 3.41\ \bar{T}^2 \tag{1.3}$$

Where $\bar{L}$ is average wave length in feet and $\bar{T}$ is average period in seconds.

The approximate average wave length of a fully arisen sea can also be expressed as:

$$\bar{L} = .67\text{"L"} \tag{1.4}$$

where "L" = $5.12T^2$, the wave length for the classic sine wave.

A.3 Fully Arisen Sea Conditions

For each wind speed there are minimum fetch (n mi) and duration (hr) values required for a fully arisen sea to exist. Table A-1 lists minimum fetch and duration values for selected wind speeds, values of significant wave (average of the highest 1/3 waves) period and height, and wave length of the average wave during developing and fully arisen seas. The minimum duration time assumes a start from a flat sea. When pre-existing lower waves exist the time to fetch limited height will be shorter. Therefore the table duration time represents the maximum duration required.

Table A-1. Fully Arisen Deep Water Sea Conditions Based on the JONSWAP Model.

Wind Speed (kt)	Minimum Fetch/Duration (n mi) (hrs)	Sig Wave (H1/3) Period/Height (sec) (ft)	Wave Length (ft)[1,2] Developing/Fully /Arisen L X (.5) /L X (.67)
10	28 / 4	4 / 2	41 / 55
15	55 / 6	6 / 4	92 / 123
20	110 / 8	8 / 8	164 / 220
25	160 / 11	9 / 12	208 / 278
30	210 / 13	11 / 16	310 / 415
35	310 / 15	13 / 22	433 / 580
40	410 / 17	15 / 30	576 / 772

NOTES:

[1] Depths throughout fetch and travel zone must be greater than 1/2 the wave length, otherwise shoaling and refraction take place and the deep water characteristics of waves are modified.

[2] For the classic sine wave the wave length (L) equals 5.12 times the period (T) squared ($L = 5.12T^2$). As waves develop and mature to fully developed waves and then propagate out of the fetch area as swell their wave lengths approach the classic sine wave length. Therefore the wave lengths of developing waves are less than those of fully developed waves which in turn are less than the length of the resulting swell. The factor of .5 (developing) and .67 (fully developed) reflect this relationship.

A.4 Wave Conditions Within The Fetch Region

Waves produced by local winds are referred to as SEA. In harbors the local sea or wind waves may create hazardous conditions for certain operations. Generally within harbors the fetch lengths will be short and therefore the growth of local wind waves will be fetch limited. This implies that there are locally determined upper limits of wave height and period for each wind velocity. Significant changes in speed or direction will result in generation of a new wave group with a new set of height and period limits. Once a fetch limited sea reaches its upper limits no further growth will occur unless the wind speed increases.

Table A-2 provides upper limits of period and height for given wind speeds over some selected fetch lengths. The duration in hours required to reach these upper limits (assuming a start from calm and flat sea conditions) is also provided for each combination of fetch length and wind speed. Some possible uses of Table A-2 information are:

1) If the only waves in the area are locally generated wind waves, the Table can be used to forecast the upper limit of sea conditions for combinations of given wind speeds and fetch length.

2) If deep water swell is influencing the local area in addition to locally generated wind waves, then the Table can be used to determine the wind waves that will combine with the swell. Shallow water swell conditions are influenced by local bathymetry (refraction and shoaling) and will be addressed in each specific harbor study.

3) Given a wind speed over a known fetch length the maximum significant wave conditions and time needed to reach this condition can be determined.

Table A-2. Fetch Limited Wind Wave Conditions and Time Required to Reach These Limits (Based on JONSWAP Model). Enter the table with wind speed and fetch length to determine the significant wave height and period, and time duration needed for wind waves to reach these limiting factors. All of the fetch/speed combinations are fetch limited except the 100 n mi fetch and 18 kt speed.

Format: height (feet)/period (seconds)
duration required (hours)

Fetch Length (n mi) \ Wind Speed (kt)	18	24	30	36	42
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
30	3-4/5 3	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3
40	4-5/5-6 4-5	5/6 4	6-7/6-7 4	8/7 4	9-10/7-8 3-4
100	5/6-7[1] 5-6	9/8 8	11/9 7	13/9 7	15-16/9-10 7

[1] 18 kt winds are not fetch limited over a 100 n mi fetch.

An example of expected wave conditions based on Table A-2 follows:

WIND FORECAST OR CONDITION

An offshore wind of about 24 kt with a fetch limit of 20 n mi (ship is 20 n mi from the coast) is forecast or has been occurring.

SEA FORECAST OR CONDITION

From Table A-2: If the wind condition is forecast to last, or has been occurring, for at least 3 hours:

Expect sea conditions of 4 feet at 4-5 second period to develop or exist. If the condition lasts less than 3 hours the seas will be lower. If the condition lasts beyond 3 hours the sea will not grow beyond that developed at the end of about 3 hours unless there is an increase in wind speed or a change in the direction that results in a longer fetch.

A.5 Wave Climatology

The wave climatology used in these harbor studies is based on 11 years of Mediterranean SOWM output. The MED-SOWM is discussed in Volume II of the U.S. Naval Oceanography Command Numerical Environmental Products Manual (1986). A deep water MED-SOWM grid point was selected as representative of the deep water wave conditions outside each harbor. The deep water waves were then propagated into the shallow water areas. Using linear wave theory and wave refraction computations the shallow water climatology was derived from the modified deep water wave conditions. This climatology does not include the local wind generated seas. This omission, by design, is accounted for by removing all wave data for periods less than 6 seconds in the climatology. These shorter period waves are typically dominated by locally generated wind waves.

A.6 Propagation of Deep Water Swell Into Shallow Water Areas

When deep water swell moves into shallow water the wave patterns are modified, i.e., the wave heights and directions typically change, but the wave period remains constant. Several changes may take place including shoaling as the wave feels the ocean bottom, refraction as the wave crest adjusts to the bathymetry pattern, changing so that the crest becomes more parallel to the bathymetry contours, friction with the bottom sediments, interaction with currents, and adjustments caused by water temperature gradients. In this work, only shoaling and refraction effects are considered. Consideration of the other factors are beyond the resources available for this study and, furthermore, they are considered less significant in the harbors of this study than the refraction and shoaling factors.

To determine the conditions of the deep water waves in the shallow water areas the deep water conditions were first obtained from the Navy's operational MED-SOWM wave model. The bathymetry for the harbor/area of interest was extracted from available charts and digitized for computer use. Figure A-1 is a sample plot of bathymetry as used in this project. A ray path refraction/shoaling program was run for selected combinations of deep water wave direction and period. The selection was based on the near deep water wave climatology and harbor exposure. Each study area requires a number of ray path computations. Typically there are 3 or 4 directions (at 30° increments) and 5 or 6 periods (at 2 second intervals) of concern for each area of study. This results in 15 to 24 plots per area/harbor. To reduce this to a manageable format for quick reference, specific locations within each study area were selected and the information was summarized and is presented in the specific harbor studies in tabular form.

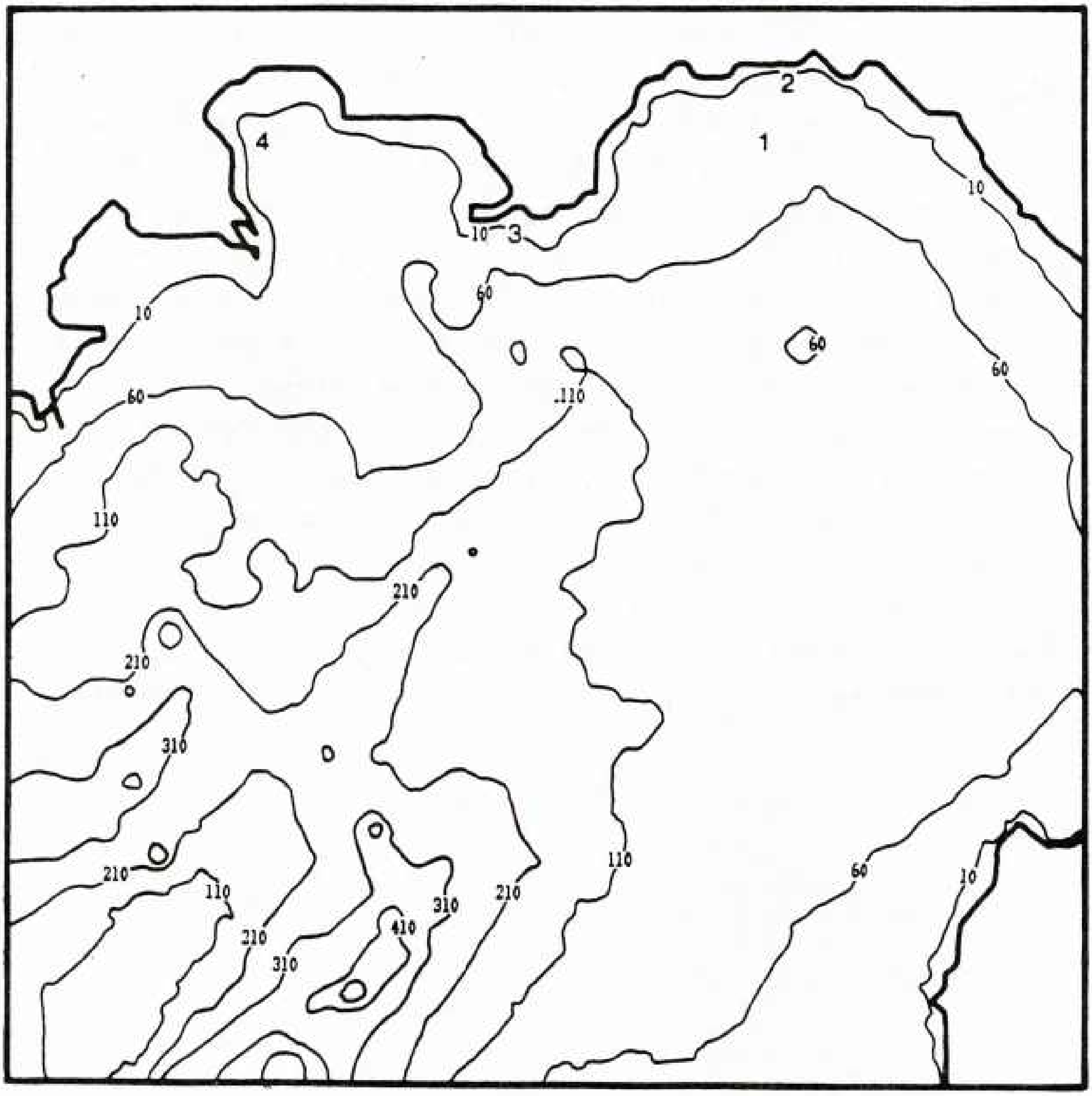

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathoms to 110 fathoms, and at 100 fathom intervals thereafter. The larger size numbers identify specific anchorage areas addressed in the harbor study.

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